NASA Electronic Parts and Packaging Program (NEPP)

FINAL

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FY01 Proposal Format

Title: Evaluation of COTS Power GaAs MMIC on diamond substrates

(check one): **x** New Proposal ☐ Continuing NEPP Work

Total $ Requested for FY01: $110K

Technology Type: **x** Newly Available (COTS) ☐ Emerging/Advanced
(check one)

Project Area: ☐ Parts **x** Packaging ☐ Radiation
(check one)

☐

Proposing Centers: Center A (GSFC)

Participating Center(s): **100**% GSFC ☐ % GRC ☐ % LaRC ☐ % JPL
☐ % MSFC ☐ % JSC ☐ Other

(Estimated Center Participation, %$):

Collaborators: Motorola, Norton

Point of Contact:
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Investigator:

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Objective(s):

Demonstrate the advantages of using diamond substrates for power GaAs MMIC
Validate processes for reliable assembly of GaAs MMICs on diamond
Demonstrate acceptable thermal performance of diamond substrates fabricated with electrical ground plane vias beneath the MMIC
Demonstrate acceptable RF and thermal performance of diamond substrate based devices in advanced Motorola RF systems such as the X-band transmitter.
Advance usage of COTS MMICs for NASA through innovative packaging.

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Task Description: In FY00 Motorola is under contract to GSFC to develop a process for utilization of Triquint 9083 X-band power MMIC on diamond. The Triquint 9083 is a COTS MMIC being considered for X-band transmitter applications. In FY00, GSFC and Motorola are sharing the design and process development tasks culminating in a production of a number of evaluation samples by GSFC and Motorola. In FY01 and FY02 we propose to perform thermal, electrical and mechanical characterization on 9083 MMICs on diamond using the production process developed in FY00

Task Approach to Meeting NEPP Objectives: Successful completion of this task will expedite the infusion of MMIC on diamond technology in critical spaceborne applications (transmitters, solid power amplifiers) where high RF power, thermal considerations and dielectric compatibility are important. In FY00 all of the important R & D aspects of the packaging development will be completed. FY01 and FY02 will concentrate on evaluation of power MMICs on diamond

Technical Background: Diamond has a thermal conductivity of ~ 20 W-cm/K gives it a large advantage over a conventional material such as BeO at 2.2 W-cm/K. Power RF MMICs for satellites will entail high thermal densities Use of diamond as a substrate material provides an obvious advantage to improve the thermal characteristics and increase overall reliability. At the same time, diamond has very low CTE ~ 10^{-6}/K compared to Alumina at ~ 6 x 10^{-6}/K, which makes it a favorable material to work in microelectronic applications. It achieves both of these properties while maintaining a reasonable density of ~ 3.5 g/cm^{3,}. Silicon is ~ 2 g/cm^3. It has a favorable dielectric constant ~ 5.7 which making it quite acceptable for RF applications. Small satellite RF chains on diamond will have a number of structural, manufacturing and performance advantages.

Motorola is a world leader in the development of microwave components and systems for space applications. Their participation in this effort demonstrates the corporate importance being attached to the work.

Norton has participated in a number of diamond substrate development efforts with GSFC and is world leader in the production of CVD diamond for electronic applications.

Technical Approach: X-band power MMICs will be mounted on as-finished and polished CVD diamond substrates and subjected to MIL-PRF-38534 regimen of testing and additional specialized tests such as C-SAM evaluation of die attach, thermal IR imaging. After rigorous evaluation, completed devices will be tested in an X-band transmitter. Successful completion of this evaluation will lead to a wider of infusion of diamond substrates in power RF and DC applications for spaceflight use.

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NASA Customers: Any program planning to use S-band, L-band, X-band or Ku-band Solid State Power Amplifiers populated with discrete or MMIC MESFET technology. This would include SMEX,SMEX-LITE,MIDEX class missions. Post 2002 notional missions, NPOESS, HORIZON, NGST, advanced EOS missions, Jupiter Polar Orbiter, Europa Orbiter,GLAST, GED.

Clearly Stated Deliverables:
(Bullet Form)
Accelerated life test results for MMIC on diamond
Process evaluation report for all assembly processes involving diamond
Failure analyses/Destructive Physical Analyses
FEA for GaAs MMIC on Diamond
Comparison of the as-finished and polished substrate performance

Top Level Schedule:
FY01/Q1 Detailed test plan (DC, RF, thermal, mechanical) and sampling plan based on actual funding
FY01/Q2 Assemble test units, baseline electrical and RF test data
FY01/Q3 MIL-PRF-38534 style testing begins
FY01/Q4 Thermal and mechanical FEA
FY02/Q1 Thermal and mechanical test report
FY02/Q2 Interim Electrical test report
FY02/Q3 RF Performance Report
FY02/Q4 Final Report

Leveraging: Leveraging will be against funding provided by Nanosat for diamond applications.